

WellHead Protection Area Delineation Methods

There are five primary delineation methods selected for use in California, in order of increasing technical sophistication.

1. Arbitrary fixed radius
2. Calculated fixed radius
3. Analytical methods
4. Hydrogeologic mapping
5. Numerical flow/transport models

The methods range from simple, inexpensive methods to highly complex and costly ones. It is important to note that more than one method can be used to determine the wellhead protection area for a well. See the attached guidance for the appropriate method(s) to use in a particular case. Listed below is a description of each method.

Arbitrary Fixed Radius

This method involves drawing a circle of a specified radius around a well being protected. The radius of the WHPA may be an arbitrarily selected distance value. Although it may appear that protection areas delineated by this method are not based on scientific principles, the distance criteria's threshold may be based on very generalized hydrogeologic considerations and/or professional judgment. As proposed for the California wellhead protection program, this method is only acceptable for non-community systems that do not know the pumping rate of the well.

Calculated Fixed Radius

This method involves drawing a circle around a well for a specified time-of-travel criterion. A radius is calculated using an equation that is based on the volume of water that will be drawn to a well in the specified time. The input data required by the equation includes the pumping capacity of the well, the screened interval of the well, and the porosity of the aquifer. The time period to be used is described in the wellhead protection area delineation guidance. If the screened interval is unknown, a value of 10 feet can be assumed for an initial assessment. Similarly, if the porosity is unknown, a value of 0.22 can be used for the initial calculation. This method provides more accuracy than the arbitrary fixed radius method, but may still be inaccurate because it does not take into account the rate or direction of groundwater flow, and other factors that may influence contaminant transport.

Analytical Methods

These methods involve the use of equations to define groundwater flow and contaminant transport. The uniform flow equations (Todd, 1980) are often used to define the area of contribution to a pumping well in a sloping water table. These are the most widely used methods for accurately determining wellhead protection areas.

These methods require the input of various hydrogeologic parameters to calculate the distance to the downgradient divide, or stagnation point, and the width of the zone of contribution to the well. The upgradient extent of the wellhead protection area can then be calculated based on either a time-of-travel or flow boundaries criterion. Site specific hydrogeologic parameters are required as input data for each well at which the method is applied. These parameters can include the transmissivity, porosity, hydraulic gradient, hydraulic conductivity, and saturated thickness of the aquifer.

Hydrogeologic Mapping

In many hydrogeologic settings, flow boundary and time-of-travel criteria can be mapped by geological, geophysical, and dye tracing methods. The flow boundaries are defined by lithologic variation or permeability contrasts within the aquifer. Geological observations may provide surface indications of lithology changes, which will correlate with wellhead protection area boundaries. Hydrogeologic mapping may also include mapping of ground water levels in order to identify groundwater drainage divides.

This method for delineating wellhead protection areas may be particularly useful for shallow aquifers, and for karst or fractured rock aquifers.

Numeric Flow/Transport Models

WellHead protection areas can be delineated using computer models that approximate groundwater flow and/or solute transport equations numerically. A wide variety of numerical models are presently available both commercially and through various organizations.

Numeric flow/transport models are particularly useful for delineating wellhead protection areas where boundary and hydrogeologic conditions are complex. Input data may include such hydrogeologic parameters as permeability, porosity, specific yield, saturated thickness, recharge rates, aquifer geometries, and the locations of hydrologic boundaries. Solute transport parameters such as dispersivity may also be incorporated in these models.